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SNOWY PLOVERS SELECT OPEN HABITATS FOR COURTSHIP SCRAPES AND NESTS

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Abstract. The population decline of the Western Snowy Plover (*Charadrius alexandrinus nivosus*) along the Pacific coast of the U.S., has been attributed, in part, to the spread of European beachgrass (*Ammophila arenaria*), which degrades nesting habitats. We compared *Ammophila* cover at the plover's courtship scrapes and nest sites with that at random locations in coastal northern California. *Ammophila* cover around nests and scrapes was significantly less than random points at several spatial scales (≤100 m) of analysis; cover around nests was also less than around scrapes. Incubating plovers ceased incubation and left nests when an observer approached to within a mean distance of 80 ± 33 m ($n = 8$). We conclude that the plover's selection of open habitats for courtship and nesting may facilitate early detection of predators. Our results indicate a minimum size for restoration projects and a distance at which fencing around nests should be placed to ameliorate the effects of human disturbance on incubating plovers.

Key words: Ammophila, Charadrius alexandrinus nivosus, *habitat restoration, nest-site selection, Snowy Plover.*

Charadrius alexandrinus nivosus Selecciona Ambientes Abiertos para sus Áreas de Cortejo y sus Nidos

Resumen. La disminución poblacional de *Charadrius alexandrinus nivosus* a lo largo de la costa Pacífica de los Estados Unidos se ha atribuido parcialmente a la expansión de *Ammophila arenaria*, una planta que degrada los hábitats de anidación. Comparamos la cobertura de *Ammophila* en las áreas de cortejo y de los nidos de *C. a. nivosus* con la de lugares aleatorios en la costa del norte de California. La cobertura de *Ammophila* alrededor de los nidos y de las áreas de cortejo fue significativamente menor que en los puntos ubicados aleatoriamente a varias escalas espaciales de análisis (≤100 m). Además, la cobertura alrededor de los nidos fue menor que aquella alrededor de las áreas de cortejo. Las aves que estaban incubando dejaron de incubar y abandonaron los nidos cuando un observador se acercó a una distancia promedio de 80 ± 33 m ($n = 8$). Concluimos que la selección de ambientes abiertos para el cortejo y la anidación en esta especie podría facilitar la detección temprana de depredadores. Nuestros resultados indican un tamaño mínimo para los proyectos de restauración y una distancia a la cual deben ponerse cercas alrededor de los nidos para disminuir los efectos del disturbio humano sobre las aves incubantes.

INTRODUCTION

Many ground-nesting shorebirds, including plovers and avocets, nest in open, sparsely vegetated habitats and depend on early detection of predators and cryptic eggs to conceal nests (Lauro and Nol 1995, Winkler 2001). Plovers in particular select open habitats with little vegetation, which facilitates early predator detection (Gochfeld 1984, Martin 1988, Cresswell 1997). Hence, variation in vegetation among and within breeding sites may influence the availability and selection of nest sites (Howe et al. 1989, Brusati et al. 2001). Understanding influences of vegetation on nest-site selection is fundamental to successful habitat management and restoration for shorebird species of special concern.

The Western Snowy Plover (*Charadrius alexandrinus nivosus*) was listed as threatened in 1993 (U.S. Fish and Wildlife Service 1993). Along the Pacific coast of the U.S., its population decline has been attributed, in part, to habitat degradation associated with the spread of European beachgrass (*Ammophila arenaria*) (Page and Stenzel 1981, U.S. Fish and Wildlife Service 1993, 2007, Page et al. 1995). Snowy Plovers typically nest in flat to gently sloping sparsely vegetated habitats, including wide ocean beaches, dry salt flats, and gravel bars (Bent 1929, Johnsgard 1981, Page et al. 1995, Colwell et al. 2005). *Ammophila* degrades the habitat by converting it to dense vegetation, which may alter the plover's behavior in selecting a nest site (Wiedemann 1984, 1987) and incubating.

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Anecdotal evidence suggests that nesting Snowy Plovers avoid habitats with dense *Ammophila*; however, few quantitative data exist to document this relationship (Willapa National Wildlife Refuge 1988, Chestnut 1997). Most analyses of the characteristics of the plover's nest site have been undertaken only at spatial scales of ≤1 m, which do not address the openness of habitats. For example, Wilson-Jacobs and Meslow (1984) reported no significant difference in *Ammophila* cover between nests and random points; in *Ammophila*-free habitats, Powell et al. (2000, 2001) found vegetation densities at nests higher than at random points. To date, no study has examined the Snowy Plover's nest-site selection and specifically addressed whether or not it selects open habitats (including *Ammophila* density). This information is required to meet recovery goals for the Western Snowy Plover's Pacific coast population (U.S. Fish and Wildlife Service 2007). Consequently, our objectives were to: (1) determine if the Snowy Plover's nest-site selection is influenced by *Ammophila* cover, (2) examine the spatial scale at which *Ammophila* influences nest-site selection, and (3) investigate the distance at which plovers respond to a simulated approach of a predator. We predicted that, if the plover's nesting habitat is degraded by *Ammophila arenaria*, the birds should select nest sites with *Ammophila* cover less than at random sites. Furthermore, if they avoid habitats with dense *Ammophila* cover because they limit early detection of predators, we expected the distance at which plovers flush from nests when approached by potential predators to be equal to the spatial scale at which *Ammophila* influences nest-site selection.

METHODS

We studied Snowy Plovers along 10 km of ocean-fronting beach (Clam Beach County Park and Little River State Beach) in Humboldt County, California. Beach width varies from 2 to 500 m. Between 10 and 32 plovers bred annually at the site from 2000 to 2006, constituting 17–56% of Humboldt County's annual breeding population (Colwell, unpubl. data). To protect nests from predators, approximately 50% of nests each year were surrounded by exclosures.

Ammophila was introduced to the local dunes in the early 1900s and has since spread and replaced native vegetation, filled previously unvegetated habitats, altered dune structure, reduced floral diversity, and dominated back-dune habitats (Buell et al. 1995). Approximately 40% of back-dune habitats are currently covered with *Ammophila.* Although sparse, the European searocket (*Cakile maritima*) and sand verbena (*Ambronia umbellata)* also grow in back-dune habitats. Flooding and scouring by the tides have left foredunes relatively free of *Ammophila*, although varying densities of pioneering sprouts are evident throughout the study area.

We examined the influence of *Ammophila* cover on the plover's nest-site selection by comparing percent *Ammophila* cover at nests, courtship scrapes, and random sites. To find nests and scrapes, we systematically searched fore- and back-dune habitats at 1- to 2-day intervals from mid March through August. Using handheld GPS units, we recorded locations of nests and scrapes and later superimposed the coordinates onto a 2005 ortho-rectified aerial photo. At each scale of analysis we generated a number of random points proportional to the number of nests. We removed any random point that occurred on a substrate other than sand (i.e., *Ammophila* or water) from the analysis and replaced it with a new random point. The numbers of nests initiated varied from 1 to 14 monthly.

Snowy Plovers typically scrape many times before selecting a nest site; consequently, the number of scrapes exceeded the number of nests (Page et al. 1995). Each month, we randomly selected a sample of scrapes proportional to the number of nests initiated so as to represent *Ammophila* cover at all scrapes during the 4-month breeding season. In this way, we were able to account for seasonal changes in the plover's scraping behavior and compare habitat characteristics of scrapes formed but not subsequently used to those eventually selected for egg laying.

To investigate the effect of spatial scale on our results and the scale at which plovers selected open habitats for nesting, we used ARCGIS to superimpose a grid of equally spaced lines onto a 2005 ortho-rectified aerial image (resolution 1 m) of the study site (USDA 2007) and circles of radii 10, 25, 50, 100, and 150 m around each nest, scrape, and random site. Spacing between grid lines increased in proportion with the concentric circles around points. Consequently, numbers of sample points (and thus power) at all scales of analysis were equal.

Ammophila dominates the landscape, and its matted texture, long slender foliage, and characteristic growth pattern clearly distinguished it from most herbaceous and woody species and made it easy to recognize in the high-resolution color photos (Buell et al. 1995). Using a point–intercept method (Heady et al. 1959), we estimated percent *Ammophila* cover by dividing the number of points where grid lines intersected *Ammophila* by the total number of line intersections within each circle. To determine if differences in *Ammophila* cover at larger scales (25, 50, 100, and 150 m) were independent of cover at smaller scales, we also estimated the percent of *Ammophila* cover independent of the area inside all circles with a smaller radius. We normalized all data with an arcsine transformation. Between 2005 and 2006, *Ammophila* cover at nests decreased by 2, 2, and 1% at 10, 25, and 50 m of analysis, respectively, and increased by 3 and 5% at 100 and 150 m of analysis, respectively. Between the two years, however, *Ammophila* cover did not differ significantly at any of the five spatial scales ($P = 0.11–0.85$). Consequently, we pooled years for analysis. We used a one-way ANOVA test to compare the mean *Ammophila* cover at nests, scrapes, and random points at each of the five spatial scales (10, 25, 50, 100, and 150 meters) and used Tukey's test to determine where significant differences lay.

Snowy Plovers do not aggressively defend nests from predators; rather, they leave nests when they detect a potential predator and rely on the eggs' crypsis and distraction behaviors to conceal the nest (Page et al. 1985, 1995). Given that little information is available regarding the distance at which incubating adults leave clutches, we conducted a simple experiment in which an observer walked directly at an incubating plover and recorded the distance at which the adult left the eggs. All trials took place in open habitats, which allowed plovers the earliest possible detection of the observer. To account for temporal variations in flushing behavior, we approached nests only between 06:30 and 09:30 (PST); we did not approach a nest twice on the same day. We summarized these data as the mean (±SD) distance at which plovers left nests and compared these distances to data on nest-site selection.

RESULTS

We sampled a total of 72 nests (36 in each year) initiated by 45 plovers (19 of which nested both years). *Ammophila* cover around nests, scrapes, and random points differed significantly within radii of 10 ($F_{2,210} = 24.32$, $P < 0.001$), 25 ($F_{2,210} = 12.46$, $P < 0.001$), 50 ($F_{2,210} = 5.30$, $P < 0.01$), and 100 ($F_{2,210} = 3.10$, $P < 0.05$) m but not within a radius of 150 m ($F_{2,210} = 0.59$, $P = 0.56$). Post-hoc Tukey's tests showed that nests occurred in more open habitats, as evidenced by significantly lower *Ammophila* cover, than did random sites at all spatial scales ≤100 m (Table 1). Results did not differ significantly when cover was analyzed independent of the area inside all circles of smaller radius. Plovers nested in more open habitats than where they scraped, as evidenced by significantly less *Ammophila* cover at all spatial scales ≤50 m (Table 1). We approached females incubating eight different nests on 37 occasions. The distance at which they flushed and days of incubation were not significantly correlated ($P > 0.05$). Female plovers left nests when observers were at a mean distance of 80 (±33 SD) m.

TABLE 1. Percent *Ammophila arenaria* cover at Snowy Plover nests, scrapes, and random sites at Clam Beach County Park and Little River State Park in Humboldt County, California, 2005–2006.

Sample radius (m)	Nest[a]		Scrape[a]		Random[a]	
	Mean	SE	Mean	SE	Mean	SE
10	6A[b]	1.35	12B	2.24	35C	4.64
25	16A	1.71	25B	2.28	37C	4.19
50	28A	2.18	35B	2.23	41B	3.81
100	40A	2.20	45AB	2.06	48B	3.40
150	48A	2.08	50A	2.07	47A	3.14

[a] $n = 71$.
[b] Row means not sharing a common letter differed significantly ($P < 0.05$).

DISCUSSION

Our study is the first to demonstrate that (1) Snowy Plovers select nest sites with significantly less *Ammophila* cover, and consequently more openness, than random sites at scales of ≤100 m, (2) when approached by a potential predator, incubating plovers flush from nests at the same scale at which they select the openness of the habitat, and (3) the openness of habitat at plover nests is significantly greater than that at scrapes.

Our study is the first to demonstrate quantitatively that Snowy Plovers select nesting habitats that are open and relatively free of *Ammophila* cover and that this selection occurs at all scales ≤100 m. The relatively large scale (~100 m) at which plovers selected *Ammophila*-free habitats suggests that restoration of the Snowy Plover's breeding habitats should assess the openness of habitats. Restoration intended to attract breeding plovers should be at a scale large enough to allow openness sufficient for nesting birds. Furthermore, fencing erected to minimize human disturbance should be placed such that people cannot approach closer than 100 m.

We showed that plovers initiated nests in habitats more open than those in which they performed courtship scraping. During courtship, males typically lead females and scrape multiple times over a period of days to weeks; females ultimately select one of these scrapes in which to lay eggs (Page et al. 1995). We found that plovers scraped in habitats slightly less open than that around nest sites, suggesting that the behaviors of courtship associated with scraping differ from nest-site selection. Although the majority of plovers at the study site were individually marked, we matched breeding pairs to nests only, not to scrapes. Consequently, we were unable to reconstruct the sequence of habitats (from courtship to egg laying) within which the birds scraped. For the role of scraping in nest-site selection to be better understood, future studies should attempt to document the chronology of scrapes leading up to egg laying. Furthermore, habitat selection is not always synonymous with habitat quality. To understand the effects of openness on the quality of habitat in which the Snowy Plover breeds, more information is needed on relationships among the openness of nest sites, nest survival, and causes of nest failure.

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